MANCHESTER 1824

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Whirlpools in space

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Summary

Many people have searched for whirlpools in the Universe. Here on Earth, they occur at sea where two different flows meet, and in the wakes of boats and ships. Elsewhere, it has been suggested that they are responsible for creating the giant storm on Jupiter, known as the Great Red Spot. At a very large scale, they may exist in the wakes of galaxies as they move through space. However, whirlpools are strangely absent at the scale of stars like our Sun. Now, we have for the first time found evidence for such whirlpools in the wakes of stars. Our hydrodynamical computer simulations have predicted whirlpools as the stars move through the clouds in interstellar space. These predictions have now been spectacularly confirmed with observations reproduced in this poster. The whirlpools can have an important role in the formation of new stars and planets in star-forming clouds. They can enhance the mixing in these clouds of elements produced in stars, such as the carbon needed for life. Further, an important parameter governing star formation is the turbulence of such clouds; whirlpools inherently provide this turbulence through their spin.

Aims of this research

We are investigating:-

- the future evolution of our Sun.
- the interaction between the old Sun, and the interstellar gas from which new stars and planets form.
- the hydrodynamics of stellar and interstellar winds.

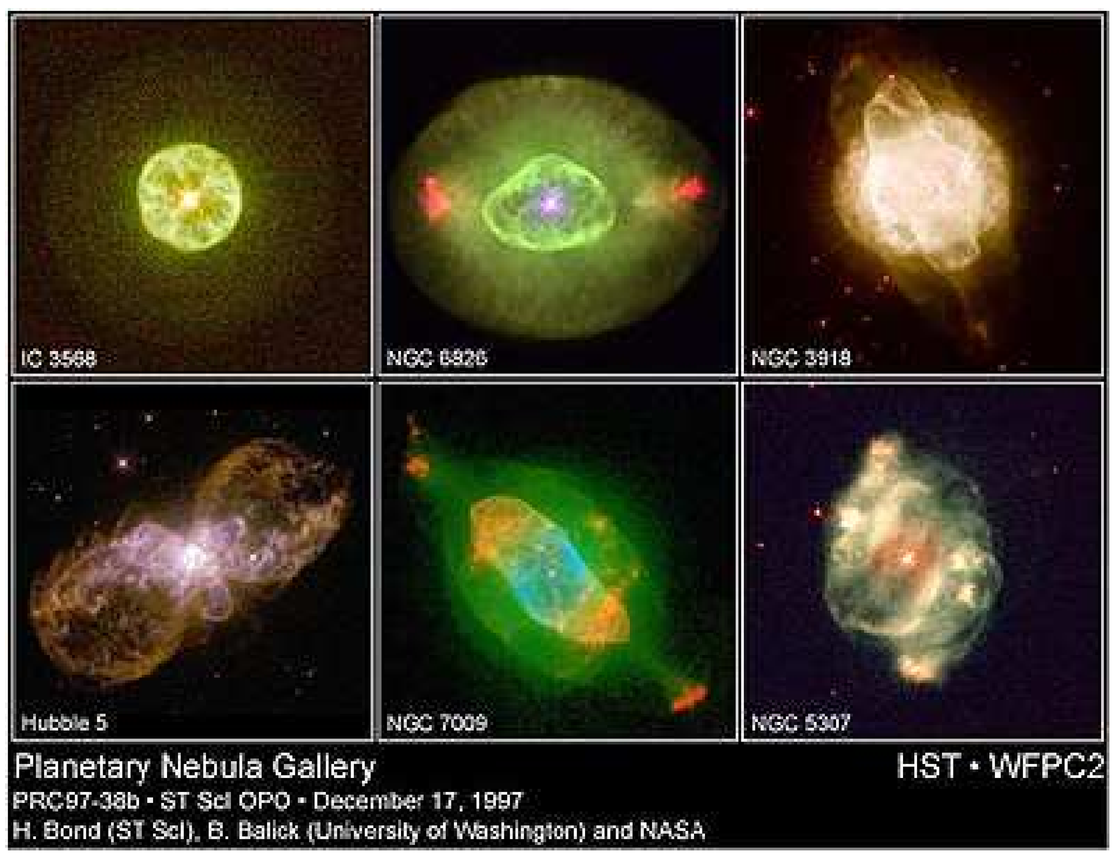

Figure 1. Different stars in the process of losing their envelopes, based on images obtained with the Hubble Space Telescope.

The future of our Sun

- The Sun will at the end of its life lose grip of its outer layers. As much as half of its mass will drift off into space. This ejected gas will contain dust (needed to form planets) and hydrocarbons (required for life), formed from the products of nuclear fusion in the Sun.

- Collisions between the ejecta and interstellar gas occur. They mix, and become part of the formation of the next generation of stars.

- Neither the ejection process nor the mixing are well understood. We aim to understand the processes by modeling the appearance of nebulae (a range of which is shown in Figure 1).

- Our models predict giant eddies and whirlpools during the mixing. These in the past have been modelled in different environments (Galaxies, disks around stars) but have never been seen in interstellar space.

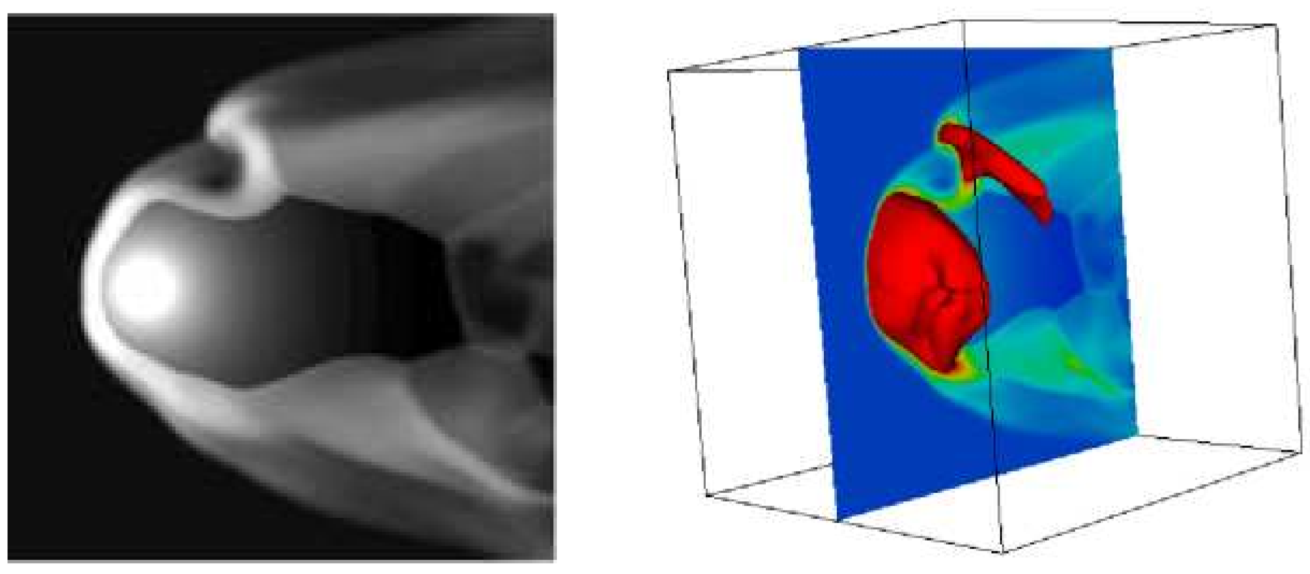

Figure 2. On the left, a slice through our simulation shows the bow shock ahead of the dying Sun. On the right is a three-dimensional representation of the same structure showing in red the bow shock and whirlpool structure downstream.

Our model

- We computer model the death of the Sun using the COBRA supercomputer at Jodrell Bank Observatory, part of the University of Manchester.

- We give the dying Sun a motion through the surrounding interstellar gas.

- The collision forms a bow shock ahead of the dying Sun.

- We suggest that the whirlpools we find in the tail are the result of instabilities at the head of the bow shock which cause whirlpool-shedding.

- Whirlpool-shedding occurs here on Earth when a fluid passes by an object and the shear layer near the object creates a velocity gradient.

Astrophysical evidence

- Comparison between predicted structures and IPHAS images taken with the Isaac Newton Telescope provides the first direct evidence for these whirlpools.

- Figure 3 shows these observations with whirlpool-generating structures indicated by arrows.

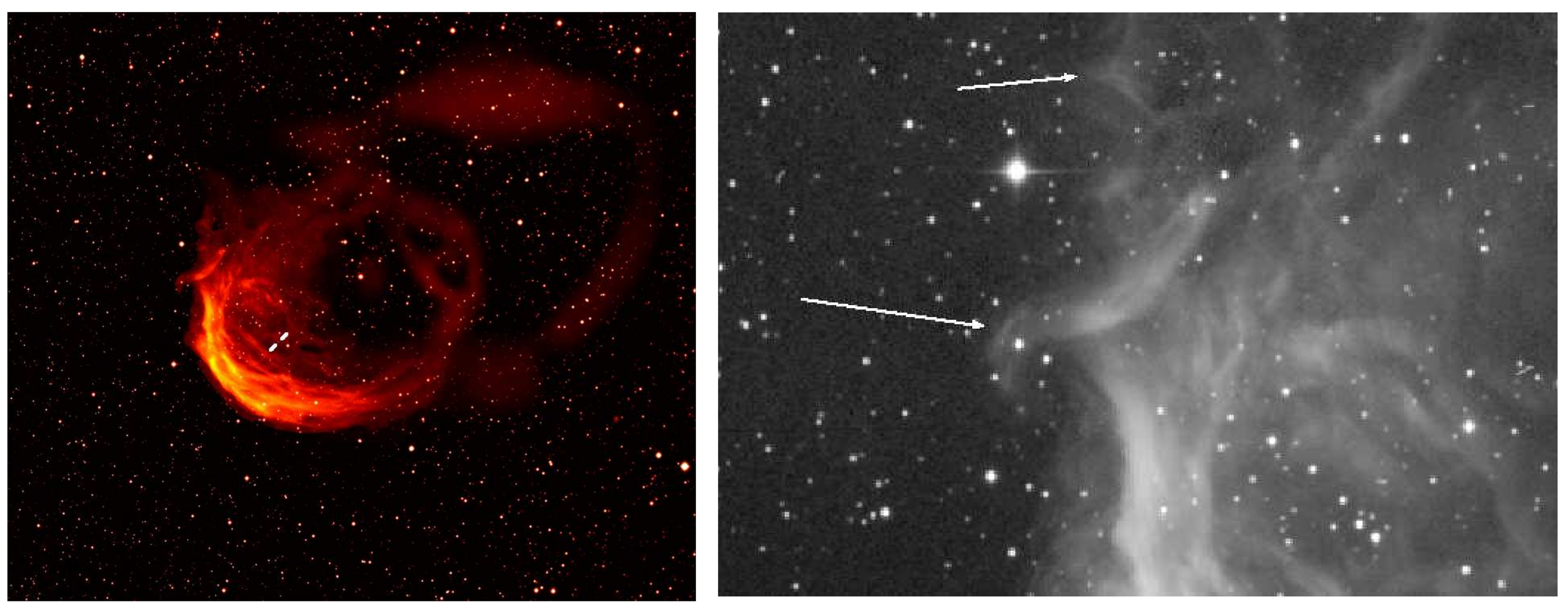

Figure 3. The left panel shows the nebula Sh 2-188 and the right panel shows a detail of the structure.

Implications

- The whirlpools improve the mixing, which benefits the next cycle of star formation.

- Angular momentum and turbulence, both inherent properties of whirlpools, are essential ingredients for star formation, but their origin up to now has been unclear.

Acknowledgements

- This work is funded by the Particle Physics and Astronomy Research Council.

- The author is a part-time Post-doctoral Research Assistant at the University of Manchester and North West Regional Coordinator for the Royal Institution of Great Britain's Science for Schools programme.

Combining the strengths of UMIST and The Victoria University of Manchester

COBRA

The University of Manchester Jodrell Bank Observatory

PPARC Particle Physics and Astronomy Research Council